

REMARKS

Claims 1-4 and 8-15 are pending in this application. Claim 1 is independent.

Applicants thank the Examiner for the courtesies extended to their representative during the August 11, 2005, personal interview.

The present invention provides a metal sheet with an anticorrosive coating formed from an anticorrosive paint containing metallic zinc powder and at least one kind of metal salt rust inhibitor, where the metal salt is a salt of a metal that is more base than zinc.

Corrosion prevention by zinc has long been known, and metal salt rust inhibitors are also known. Specification at page 4, lines 4-6.

However, the present inventors are the first to find that a marked anticorrosive effect is produced by the **combination** of zinc powder with a metal salt rust inhibitor, where the metal salt is a salt of the metal which is more base than zinc. Specification at page 4, lines 6-10.

When a solution is formed from a combination of zinc powder with a metal salt rust inhibitor whose metal is less base than zinc, ions the metal of the rust inhibitor deposit in place of zinc. Thus, zinc is ionized in place of the metal of the rust inhibitor. This promotes corrosion of the metal sheet.

As discussed in the specification at page 4, lines 10-12, the mechanism of the anticorrosive effect of the present invention is not well known. However, according to Applicants' present understanding, when pH is too high or too low, the metal salt rust inhibitor of the present invention dissolves to make the pH more neutral whereby zinc salts having a protective effect against corrosion are generated.

Claims 1-4 and 8-15 are rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 4,352,899 ("Tada").

Tada discloses a corrosion resistant coating composition on a metal substrate. Tada's composition includes 30-95 wt% zinc powder and 0.1 to 5 wt% of a magnesium compound. Tada at abstract. The particles of the magnesium compound preferably pass through a 300 mesh sieve. Tada at column 5, lines 13-15.

Any *prima facie* case of obviousness based on the cited prior art is rebutted by the significant improvement in corrosion resistance that is achieved by the present invention by the **synergistic combination** of zinc powder and metal salt rust inhibitor having an **average particle diameter no larger than $1\mu\text{m}$** . See Declaration Under 37 C.F.R. § 1.132 filed April 15, 2005, copy attached; and Fig. E from the Declaration reproduced below:

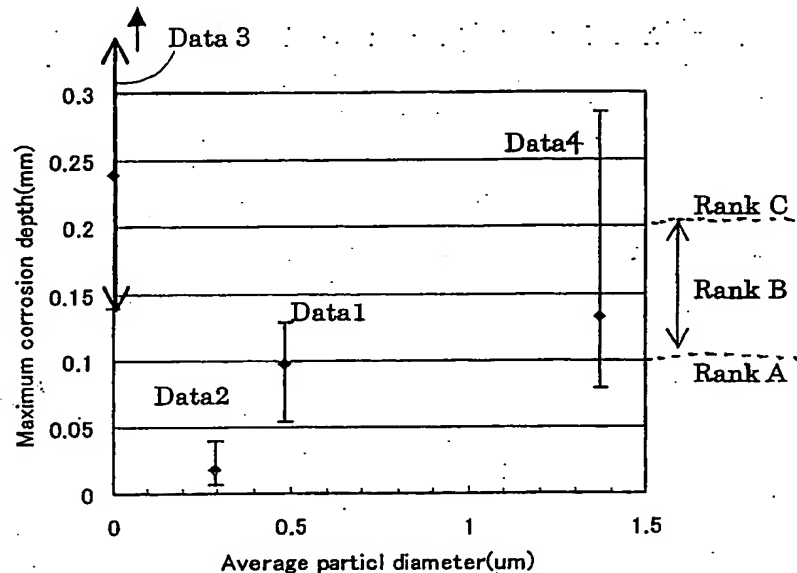


Fig. E

Fig. E shows the variation in maximum pinhole depth with average particle diameter of metal salt rust inhibitor for samples protected by anticorrosive paint (i) containing both zinc powder and metal salt rust inhibitor having an average particle diameter no larger than $1\mu\text{m}$ (Data 1 and Data 2); (ii) containing zinc powder and metal salt rust inhibitor having an average particle diameter larger than $1\mu\text{m}$ (Data 4); and (iii) containing zinc powder but no metal salt rust inhibitor (Data 3).

The Declaration at section 3 indicates that the pitting corrosion data show in Fig. E was obtained using the JASO-M609 test described in the specification at pages 7-8. The test sample corresponding to each data point was divided into sixteen equal sections. The maximum pinhole depth for each section falls within the ranges indicated for each data point in Fig. E. The average maximum pinhole depth indicated in Fig. E for each data point is the average of the sixteen maximum pinhole depths that were observed in the sixteen sections corresponding to each data point.

Pitting corrosion is a localized form of metal corrosion that results in holes in the metal. See, e.g., Corrosion Engineering, pages 48-49, copy attached. Metal failure due to pitting corrosion can occur when a single pit is long enough to extend through the metal. Thus, in Fig. E the upper value in the range of maximum corrosion depth associated with each data point is the most relevant indicator of pitting corrosion behavior.

Fig. E shows that the upper value in the range of maximum corrosion depth associated with each data point is significantly lower for Data 1 and Data 2 (which contain zinc and a metal salt rust inhibitor having an average particle diameter no larger than 1 μm) than it is for Data 4 (which contains zinc and a metal salt rust inhibitor having an average particle diameter larger than 1 μm) and Data 3 (which contains zinc powder but no metal salt rust inhibitor).

Thus, Fig. E shows that a significant improvement in pitting corrosion resistance is achieved by the present invention with a combination of zinc powder and the metal salt rust inhibitor having an average particle diameter no larger than 1.0 μm .

Tada discloses a coating composition that provides corrosion resistance against the formation of red rust. See, e.g., Tada at column 7, line 68. However, Tada is silent about pitting corrosion. Pitting corrosion is only one of eight different forms of corrosion. See, e.g., Corrosion Engineering, at page 28, copy attached.

Tada fails to suggest the significant improvement in pitting corrosion resistance that achieved by the present invention with a combination of zinc powder and the metal salt rust inhibitor having an average particle diameter no larger than 1.0 μm .

Thus, any *prima facie* case for the obviousness of independent Claim 1 is rebutted. Because the cited prior art fails to have rendered obvious the claimed invention, the prior art rejections should be withdrawn.

In view of the foregoing remarks, Applicants respectfully submit that the application is in condition for allowance. Applicants respectfully request favorable consideration and prompt allowance of the application.

Should the Examiner believe that anything further is necessary in order to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned attorney at the telephone number listed below.

Respectfully submitted,

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Attached:

Declaration Under 37 C.F.R. § 1.132 filed April 15, 2005, and date-stamped filing receipt
Corrosion Engineering, pages 28-29; 48-49

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EIGHT FORMS OF CORROSION 3

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It is convenient to classify corrosion by the forms in which it manifests itself, the basis for this classification being the appearance of the corroded metal. Each form can be identified by mere visual observation. In most cases the naked eye is sufficient, but sometimes magnification is helpful or required. Valuable information for the solution of a corrosion problem can often be obtained through careful observation of the corroded test specimens or failed equipment. Examination *before* cleaning is particularly desirable.

Some of the eight forms of corrosion are unique, but all of them are more or less interrelated. The eight forms are: (1) uniform, or general attack, (2) galvanic, or two-metal corrosion, (3) crevice corrosion, (4) pitting, (5) intergranular corrosion, (6) selective leaching, or parting, (7) erosion corrosion, and (8) stress corrosion. This listing is arbitrary but covers practically all corrosion failures and problems. The forms are not listed in any particular order of importance.

Below, the eight forms of corrosion are discussed in terms of their characteristics, mechanisms, and preventive measures. Hydrogen damage, although not a form of corrosion, often occurs indirectly as a result of corrosive attack, and is therefore included in this chapter.

UNIFORM ATTACK

Uniform attack is the most common form of corrosion. It is normally characterized by a chemical or electrochemical reaction which proceeds uniformly over the entire exposed surface or over a large area. The metal becomes thinner and eventually fails. For example, a piece of steel or zinc immersed in dilute sulfuric acid will normally dissolve at a uniform rate over its entire surface. A sheet iron roof will show essentially the same degree of rusting over its entire outside surface. Figure 3-1 shows a steel tank in an abandoned gold-smelting plant. The circular section near the center of the photograph was thicker than the rest of the tank. This section is now supported by a "lace curtain" of tank bottom metal.

Uniform attack, or general overall corrosion, represents the greatest de-

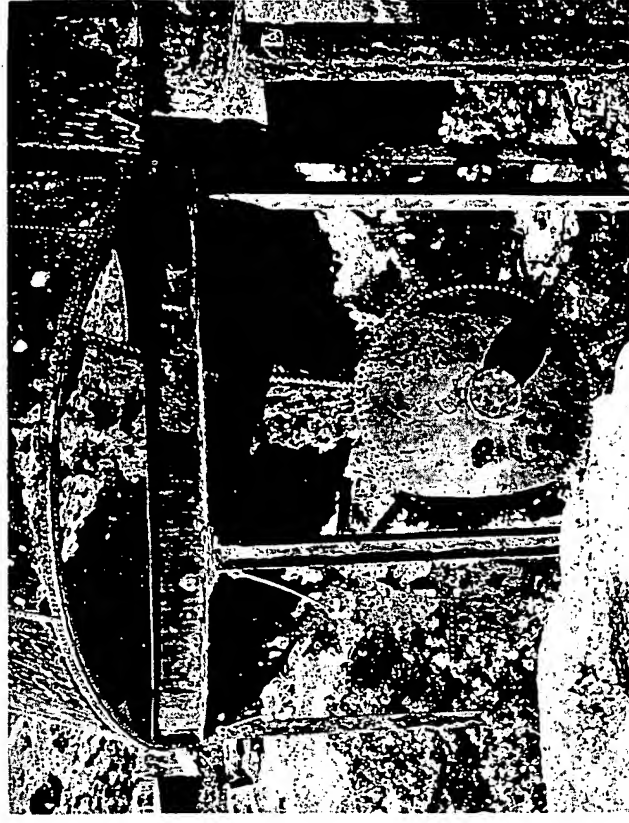


Fig. 3-1. Rusting of abandoned steel tank.

struction of metal on a tonnage basis. This form of corrosion, however, is not of too great concern from the technical standpoint, because the life of equipment can be accurately estimated on the basis of comparatively simple tests. Merely immersing specimens in the fluid involved is often sufficient. Uniform attack can be prevented or reduced by (1) proper materials, including coatings, (2) inhibitors, or (3) cathodic protection. These expedients, which can be used singly or in combination, are described further in Chap. 6.

Most of the other forms of corrosion are insidious in nature and are considerably more difficult to predict. They are also localized; attack is limited to specific areas or parts of a structure. As a result, they tend to cause unexpected or premature failures of plants, machines, or tools.

GALVANIC OR TWO-METAL CORROSION

A potential difference usually exists between two dissimilar metals when they are immersed in a corrosive or conductive solution. If these metals are placed in contact (or otherwise electrically connected), this potential difference produces electron flow between them. Corrosion of the less corrosion-resistant metal is

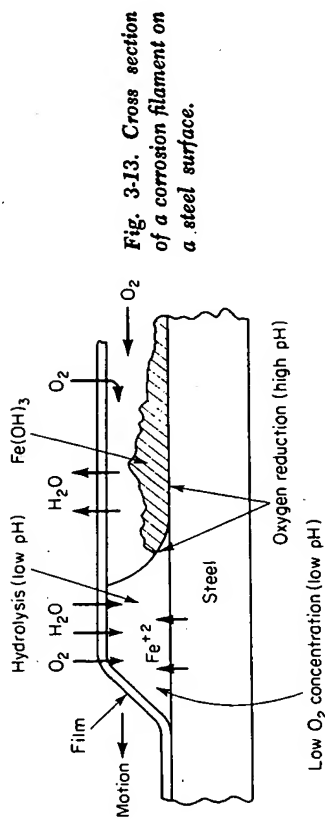


Fig. 3-13. Cross section of a corrosion filament on a steel surface.

PREVENTION There is no completely satisfactory way to prevent filiform corrosion. An obvious method is to store coated metal surfaces in low-humidity environments. Although this technique can be used in some instances, it is not always practical for long-time storage. Another preventive measure which has been employed consists of coating with brittle films. If a corrosion filament begins growing under a brittle coating, the film cracks at the growing head. Oxygen is then admitted to the head, and the differential oxygen concentration originally present is removed and corrosion ceases. However, as noted above, corrosion filaments usually start at edges. Hence, a new corrosion filament begins at the point of rupture. Although brittle films suppress the growth rate of corrosion filaments, they do not offer much advantage since articles coated with such film must be handled very carefully to prevent damage. Recent developments with films of very low water permeability hold some promise in preventing filiform corrosion.

PITTING

Pitting is a form of extremely localized attack that results in holes in the metal. These holes may be small or large in diameter, but in most cases they are relatively small. Pits are sometimes isolated or so close together that they look like a rough surface. Generally a pit may be described as a cavity or hole with the surface diameter about the same as or less than the depth.

Pitting is one of the most destructive and insidious forms of corrosion. It causes equipment to fail because of perforation with only a small percent weight loss of the entire structure. It is often difficult to detect pits because of their small size and because the pits are often covered with corrosion products. In addition, it is difficult to measure quantitatively and compare the extent of pitting because of the varying depths and numbers of pits that may occur under identical conditions. Pitting is also difficult to predict by laboratory tests. Sometimes the pits require a long time—several months or a year—to show up in actual service. Pitting is particularly vicious because it is a localized and intense form of corrosion, and failures often occur with extreme suddenness.

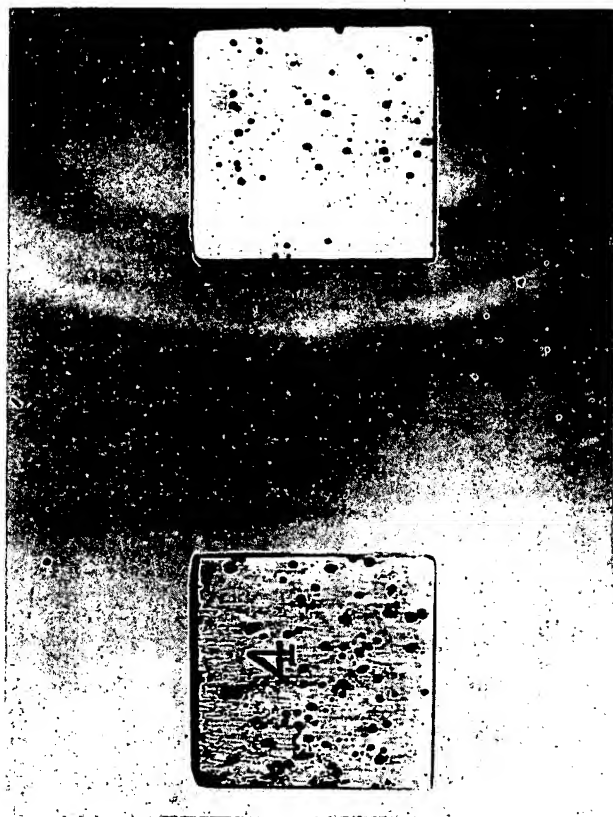


Fig. 3-14. Pitting of 18-8 stainless steel by acid-chloride solution.

3-11 Pit Shape and Growth Figure 3-14 is an example of pitting of 18-8 stainless steel by sulfuric acid containing ferric chloride. Note the sharply defined holes and the lack of attack on most of the metal surface. This attack developed in a few days. However, this is an extreme example, since pitting usually requires months or years to perforate a metal section. Figure 3-15 shows a copper pipe that handled potable water and failed after several years' service. Numerous pits are visible, together with a surface deposit.

Pits usually grow in the direction of gravity. Most pits develop and grow downward from horizontal surfaces. Lesser numbers start on vertical surfaces, and only rarely do pits grow upward from the bottom of horizontal surfaces.

Pitting usually requires an extended initiation period before visible pits appear. This period ranges from months to years, depending on both the specific metal and the corrosive. Once started, however, a pit penetrates the metal at an ever-increasing rate. In addition, pits tend to undermine or undercut the surface as they grow. This aspect illustrated in Fig. 3-16 shows a magnified section of a



Fig. 3-15. Pitting of a copper pipe used for drinking water.

To our Families

CORROSION ENGINEERING

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